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MK-Astro

User's manual

MKFocus mark II

Introduction

Thank You for choosing *MK-Astro* product. We wish You enjoy the device, as it was designed and built to last. We believe our hobby is experienced best through years of enjoyment, thus we promise our equipment would endure and provide for seamless operation and sustained performance.
In case of any signs of trouble please contact us immediately at contact@mk-astro.com. We're also open to suggestions / opinions / ideas You may have.

Basic features

MKFocus mark II controller was designed with two primary modes of operation:

- ✓ Standalone, with no computer connection and direct user interaction
- ✓ Automated, where the module acts as an extension to the computer system, following RoboFocus®[1] protocol

We were successful in incorporating both of these functionalities in one device, resulting in clear controls, easily readable display, USB interface and flexible output for uni- and bi-polar motors control.

1 RoboFocus® is the registered trademark of Technical Innovations

Focusing principles

In our opinion focusing renders second critical element of the successful astrophotography run (being preceded only by the quality of mount's mechanics to accurately follow the stars). Focusing system must therefore deliver precision, repeatability, heavy equipment driving capacity and thermal stability. Every single astrophotographer experienced difficulties in obtaining tack-sharp images - and this presents the same challenge every time the imaging run is in progress. Provided a decent focuser is in use and equipped with a stepper motor, it would also allow for automated focusing using *MK-Astro* device.

One of the important elements to mention, the faster the scope (lower F ratio) the more demanding focusing becomes. In a very simplified form the sweet-spot range of perfect focus is given by the following equation:

$$NCFZ = 0.00225 * \theta_{FWHM} * \sqrt{\tau} * A * f^2$$

Where:

NCFZ - New Critical Focus Zone (micrometers)
θ_{FWHM} - total seeing (arc seconds)
τ - focus tolerance as a percentage of total seeing (unit less)
A - telescope aperture (millimeters)
f - effective imaging system f/ratio (unit less)
0.00225 - constant (micrometers per arc second per millimeter)

Calculation examples:

1. Sky90, working with FR/FF at F/4.5 would require focusing accuracy of:
$$NCFZ = 0.0025 * 3.0 * \sqrt{15} * 90 * 4.5^2 = 53\ [\mu m]$$
2. Same scope, now working at its native F/5.56:
$$NCFZ = 0.0025 * 3.0 * \sqrt{15} * 90 * 5.56^2 = 80\ [\mu m]$$
3. Same scope, now consider an extender Q plugged-in (F/8.89):
$$NCFZ = 0.0025 * 3.0 * \sqrt{15} * 90 * 8.89^2 = 204\ [\mu m]$$

(all examples – 3 arc sec as a mean seeing, and 15% focusing accuracy)

A rule of the thumb - good results will always demand focusing accuracy to be better than calculated for particular equipment.

Reaching required accuracy not only asks for rigid design of the focuser, but also proper selection of the driving motor. If the focuser shaft is being driven directly, then the stepper must be equipped with gearbox, allowing for positioning two or more times better than the calculated focusing requirement. For the cited examples this would mean absolute **maximum** step size of 25, 40 and 100 µm, respectively.

To visualize the difference between almost-sharp and tack-sharp image please take a closer look at the magnified part of the actual images (taken via Newtonian):


This image suffers from slight misfocus, while that one:

clearly shows long and colorful diffraction spikes (a good focusing indicator).

Benefits of assisted operation (without touching the main telescope) become obvious for visual observing as well. Although focusing within that application is much less demanding (due to our subjective nature and individual preferences), elimination of

user-induced vibrations, convenience of operation, and position-aided repeatability (e.g. for use of different eyepieces) places this method way ahead of manual operation. Position display adds further to the ease of handling in various situations.

The *MK-Astro* MKFocus mark II controller answers to all these requirements, offering unprecedented ability to ensure both the autonomous and computer-aided operation.

Controls, designed to operate and (to the some extent) reprogram basic parameters along with clear red LED night display will allow for standalone experience. User would be able to take advantage of varying motor speed movement, while staying in full control and watching current position on the display. To further adapt the device to night operation requirements, blank-display function has been employed, dimming the display to just single dot after a few seconds of inactivity.
In computer-connected environment an USB port was considered as the most flexible option, allowing for serial communication. This allows for operation as RoboFocus® mimicry controller, implementing entire protocol (remote switch operation is emulated but not implemented in hardware).

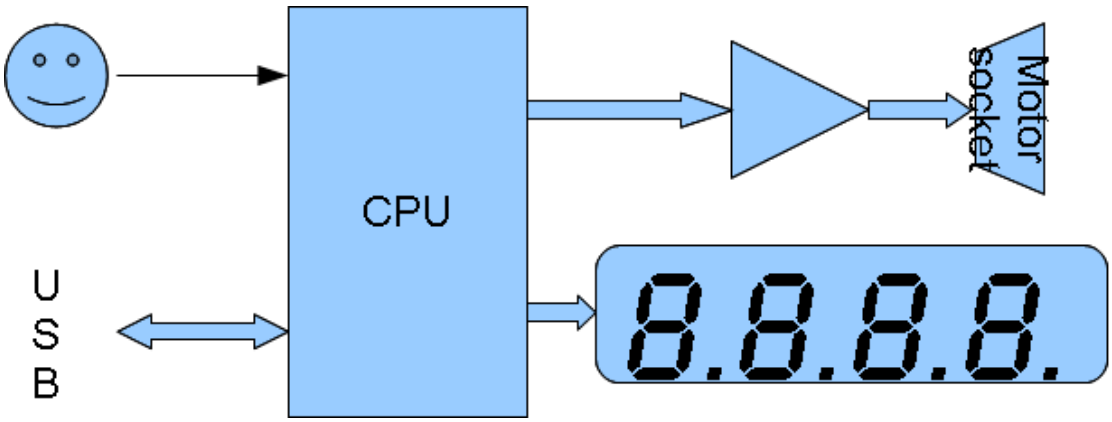
To add further flexibility, the module provides driver capable of operating uni- or bi-polar motors.

Functions

Controller design

MKFocus device has been built to last, using various safeguards and proven technical design. Its primary function (focus motor control) is supported by dual input interface – control switches and USB port. Former have direct control upon movement of motor, latter – require RoboFocus® compatible protocol input to operate the motor / reprogram module.

Block diagram of the device:



Functional description:

- CPU provides for entire device control
- User input via two switches available on the front panel
- USB emulates serial port, allowing for communication with the device

- LED display (7-segment, four digits) has been specially adapted, and is capable of showing current position within 0..65535 range (blanks in screen-saver mode)
- Motor driver (full H-bridge) allows for control of uni- or bi-polar steppers
- Safety switches input via motor socket ensures safeguard against positioning the focuser beyond its mechanical limits

CPU has been programmed to support entire RoboFocus® protocol. Connections are described in the chapter "Connecting the module". Reception of user inputs or proper command over the computer interface result in issuing stepper control signals, in accordance to the current configuration. Basic parameters (step size, direction and delay) may be reprogrammed without computer connection. Other parameters (as of RoboFocus® specs) are available for reprogram while the device is connected to the computer. For reference please look at the "Computer operation" or "Manual operation" chapters.
In computer-less mode the user input is translated into varying motor speed, allowing for convenient, high speed end-to-end swings. Initial speed (right after pushing any of the buttons) is just one step per button tap / single press of a duration under 0.2s, to precisely get into desired position. This adds further to the user feel and experience.
For electric connection diagrams, please refer the "Connecting the module" chapter.

ATTENTION: Unless the limiting switches are connected the system is vulnerable to mechanical failure, once the stepper is being driven beyond physical limits of the focuser. High stepper torque and motor gear ratio may together lead to damage of the focuser, if the stepper continues to move. It is up to the user to either ensure there is safety clutch between motor and focuser shafts or safety switches (for connection please refer to the "Connecting the module" chapter) are installed.

Manual operation

After connecting only the motor and power supply, the MKFocus mark II immediately enters manual operation at the command of the user. Start-up and restore of saved configuration is signaled by series of beeps and LED flashes. Upon successful completion of internal tests the device will display current temperature for one second, then the display will show last saved position (if operated via computer interface). Pushing any of the buttons (marked UP and DOWN on the front panel) will result in focuser motor movement. Depending on the configuration (parameter: *direction*) the motor will run CW / CCW upon pushing UP button and in the opposite direction while DOWN is depressed. A tap or single press lasting less than 0.2s (any button) will move the motor a single step in the desired direction; press&hold activates vari-speed function. The motor will start at a predefined low speed, then it will speed up to the target full speed (controlled by the parameter: *delay*). Current position of the motor will be displayed. When the pressed button is released and motor movement ceases the controller will beep once, confirming end of move. After a few seconds of inactivity, display will be switched off (save single dot). Purpose of that is to reduce unnecessary light and allow for preservation of full dark adaptation of the observer. Current position is preserved – unless the device is powered off, the screen saver just blanks the screen and the main circuitry is operational still.

Display

To understand how range of 0…65536 is displayed on just four digits display it is necessary to observe the decimal dots. These represent the binary code of tens of thousands. Range of 0..9999 is displayed directly as 0 0 0 0 to 9 9 9 9, respectively. Crossing 10000 will show single dot to the right of the last display digit, resulting in range 10000..19999 representation being 0 0 0 0. to 9 9 9 9. The same continues for next ranges, until reaching maximum (predefined as 65536 or reprogrammed via computer interface) 5 5.3.6
For quick reference please observe the following table:

Position	Display	Decoding dots
0..9999	0000 9999	no dots = direct display
10000..19999	0000. 9999.	_ _ _ _. = display + 10000
20000..29999	000.0 999.9	_ _ _._ = display + 20000
30000..39999	000.0. 999.9.	_ _ _._. = display + 30000
40000..49999	00.00 99.99	_ _._ _ = display + 40000
50000..59999	00.00. 99.99.	_ _._ _. = display + 50000
60000..65536	00.0.0 55.3.6	_ _._._ = display + 60000

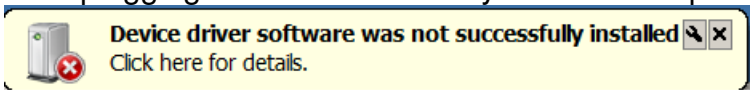
When powered for the first time the display will show the following:
000.0., which translates to 30000.

Programming
For reprogramming of the basic parameters please refer to the "Programming and interfaces" chapter.

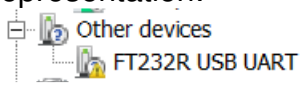
Computer operation

Addition of the USB allowed for incorporation of the control protocol (following RoboFocus® specification) and computer-aided operation. Automatic focusing, while relaying upon closed loop operation principle, becomes possible then. Startup sequence is the same as the one described in "Manual operation" section.
USB connection between the computer and the device for the very first time will require device driver installation. To do so, please insert the CD into drive, navigate to the appropriate OS-oriented folder and install the drivers. After that step a virtual COM port will be created. Please retain default port settings (9600 Baud 8N1). It is possible to reconfigure COM port number to the desired one, especially when the current software is already configured to use specific port. Port number range of 1..32 is allowed, depending upon available ports (some may already be reserved, or physically present on the target system).

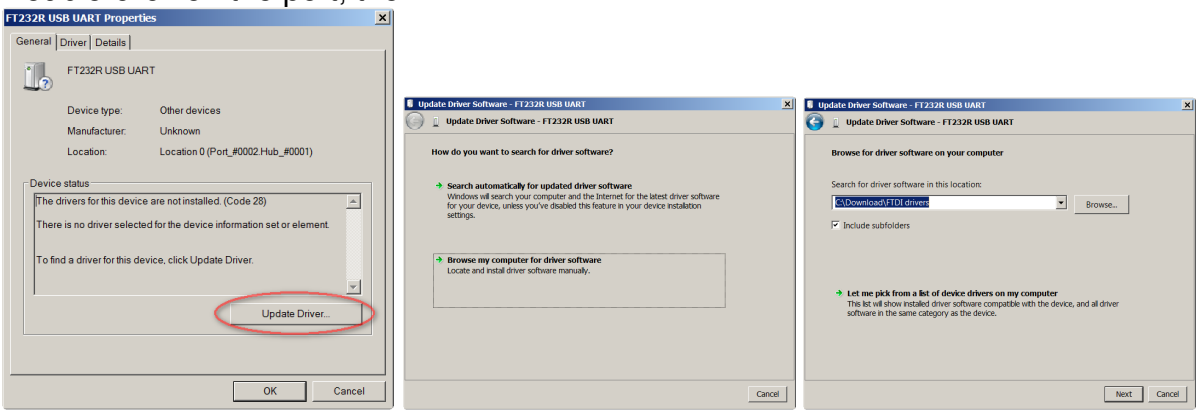
Windows 7 example:
After plugging the module in the system will complain about the drivers:



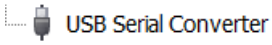
Change to My Computer -> Manage -> Device Manager, then find the port representation:

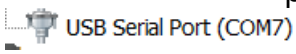


Double-click on the port, then:

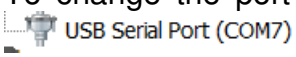


choose “Update Driver”, browse for software, then point out to the driver on CD and confirm selection by clicking on Next button.
In Windows 7 You’ll have to repeat the process twice (with the same procedure / driver):

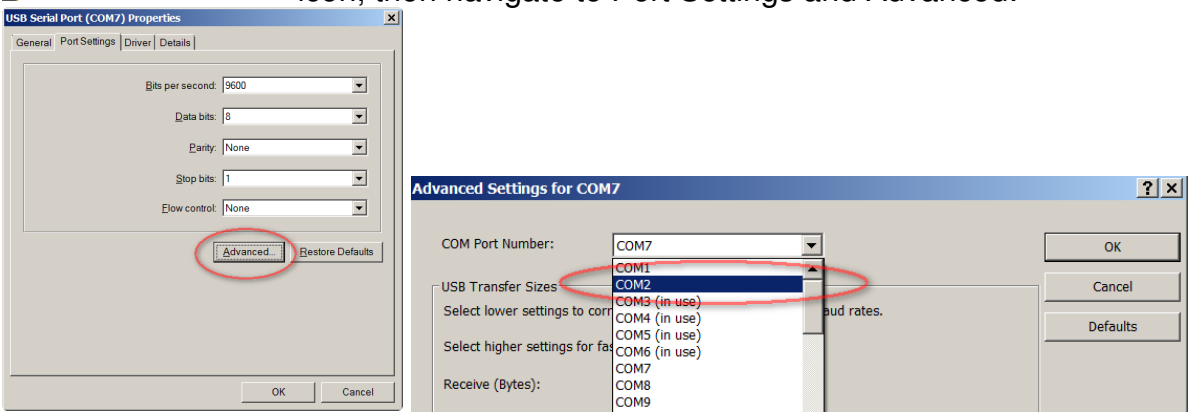
- for 

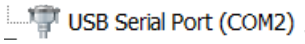
part
- for 

part

To change the port number and assign one of Your choice please click twice on 

icon, then navigate to Port Settings and Advanced:



Choose the available port, then click ok for remaining windows.


- You’re done!

It is advised to plug the module into all available USB ports and repeat driver installation (if necessary), if there is possibility to use different ports during repeated sessions. Check if the same COM port was assigned every time, and correct the port number if required. This will save the user from possible difficulties, when the module plugs into previously not used port and the installation CD is not available at the same time (the driver must be installed and operational for all applicable USB ports before operation).

After installation of standard RoboFocus® software (standalone or server version) computer-aided operation is possible. Operation of that software is in accordance to its own manual, as the entire protocol is implemented. User is just required to point out correct port number.

Important notice: Pressing of any of the buttons while the command execution is in progress will cease the motor move immediately and end command will be issued to the computer system.

For convenience of remote operation, whenever the module is connected to the PC and operated by RoboFocus® software, the focuser position is saved during the session (every time the PC reads motor configuration). New session will start exactly in the same position as the previous one ended, which helps determine absolute focuser position.

Safety switches

To ensure safety of operation and protection to the equipment the MKFocus module has been fitted with safety switches feature. Safety switches should be connected to the motor plug, pins 6-7, in NO (normally open) configuration. When using both end switches (for fully racked-in and racked-out) please connect them in parallel (please refer to the electrical characteristics topic for further connection reference).
The module is capable of recognizing the direction in which the system tripped the safety switch, and will allow 200 grace steps to retrace the focuser (including mechanical backlash, if any). Upon activation of any of the safety switches the move will be cancelled immediately, and the position returned / shown on the display. User can then retrace the focuser (either by pressing the opposite button - to the one which caused the collision alarm - or issuing reverse command). If grace steps to retrace the focuser from obstacle are exhausted then the module will stop the operation permanently, requiring the user intervention. In remote operation there is emergency workaround feature for such situation: when backlash is greater than grace steps or for any other reason retrace failed, the user should have means to remotely disable the power to the module (when it is hanging for user recovery and *not answering to any commands*) then retry the reversing operation (until the safety switch is deactivated every power up will allow fresh 200 grace steps reversal run – the module will allow only the correct recovery direction, attempts to further move the focuser beyond already-reached limit will be ignored).

Backlash compensation

Backlash compensation becomes operational (when programmed) only in computer operation mode. In manual mode the switches control the movement of the stepper motor in a direct way.
When backlash compensation is activated it will:

- check the direction of the compensation, and if the direction matches with command:
  - move the focuser backlash-controlled number of steps into that direction (high speed) plus the number of steps the command carried, then reverse the same number of steps in the opposite direction

Such algorithm has been employed to ensure any mechanical play is cancelled every time the focuser is being moved. As a result, any move, which doesn't require compensation to be executed immediately and the command to move in the opposite direction, is supplemented with compensation routine each time. This requires some extra time when focusing, however, it also ensures absolute positioning of the focuser irrespectively the direction of its movement.

The backlash compensation is not shown on the display (runs in background and cannot be canceled by buttons), and while it still operates the system LED will be blanked.

Programming and interfaces (technical specification)

RoboFocus® protocol

MKFocus mark II closely follows entire RoboFocus® protocol. In order to refer to any specific command, please refer to the RoboFocus® documentation.
Reception of the correct command is signaled by short blinking of system LED. The switches commands are recognized and answered properly, however the relays are not physically implemented within the device.

Manual programming

MKFocus mark II device offers some reprogramming functionality even when utilized in standalone mode (computer not connected). The following parameters are available for reprogramming:

- Stepper motor speed (parameter: delay)
- Software step size (parameter: step)
- Stepper motor direction

Reprogramming of those parameters is possible during device power-up:

- Power-up holding green switch - delay parameter adjustment:
  - Display shows dEL
  - Green button increases delay in a repeating cycle 1..20
  - Red button confirms selection and exits
  - To exit function without changes simply unplug the power supply
- Power-up holding red switch - step size parameter adjustment:
  - Display shows StEP
  - Green button increases step size in repeating cycle 1..255
  - Red button confirms selection and exits
  - To exit function without changes simply unplug the power supply
- Power-up holding both buttons – motor direction is changed:
  - Display may show norn or rEU
  - Direction of the motor movement will change accordingly (normal / reversed)
  - This function exits automatically

Electrical characteristics

The device accepts power supply ranging from 7 to 15V, DC (depending on the used motor, it might result in lack of torque, or overloaded and overheating motor – while in move). Every effort was taken to protect the module from wrong supply polarization and immunity against RF interference.
All connections to peripherals (motor, USB) require the power to be disconnected.

REMARK: USB input and H-brigde output are not protected beside standard peripheral safety built into the interface chips, and current limiter at the output stage. All connections must be secured before plugging in power.

USB

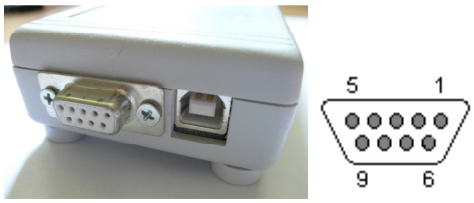
USB B-type connector has been placed on the side of module, close to motor and power supply sockets. Standard A-B USB cable (included) ensures connectivity, while the I/O of the module is capable of serving USB 2.0/1.1/1.0 standards. USB I/O is self-sustainable, which means the computer will recognize the connection immediately after plugging the device in. After connection virtual com port software driver is required – it is advisable to have the COM port assigned permanently, from all available PC sockets – in order to do so please refer to the Computer Operation section.

REMARK: Use only USB standard A-B cables to connect the device – this port is electrically unprotected otherwise than via standard I/O chip protection mechanisms.

Focuser motor connector / limiting switches socket

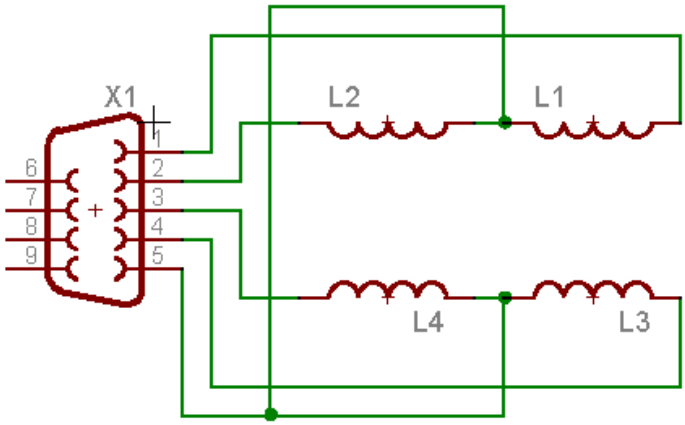
Focuser motor connector can be found on the side of the module, close to USB connector. It is marked as MOTOR on the module case. Standard female DB-9 socket is being used. The connection is compatible with original RoboFocus® design,

which ensures interoperability of motors. Connection to the focuser stepper motor is possible with DB-9M/DB-9F cable (included).

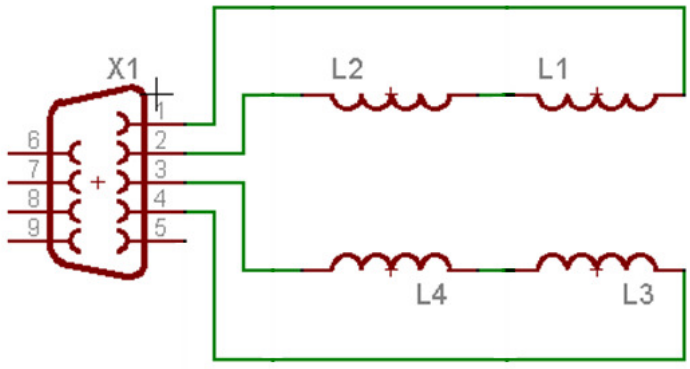


Pin	Function
1	Coil 1
2	Coil 2
3	Coil 3
4	Coil 4
5	Power supply (Ucc)
6	Limiting switch (racked in / out)
7	GND

Motor connection schematic – unipolar stepper:



Motor connection schematic – bipolar stepper:



REMARK: Focuser motor outputs are protected against overcurrent (shortage in coils).

Power supply socket

Standard 5.5/2.1mm power socket was used, with positive Ucc voltage on the central pin. Circuitry is protected against the reverse polarity / overcurrent.

Troubleshooting

The table below lists the common problems and their remediation. It is advised to consult this table first, while experiencing troubles, before contacting us.

Behavior	Possible cause	Remediation actions
System LED off	No power	• Check the power supply • Check the power supply polarity (+Ucc on the central pin) • Check the overcurrent protection – unplug the motor and try again
Display apparently off, LED on	Screen saver active	• Check if the rightmost dot is lit – tap any of the buttons / issue PC command to re-enable display
Stepper performs chaotic movements instead of turning CW / CCW	Stepper coils mixed up	• Check the coils connection against the schematic provided above; properly reconnect coils
Stepper is not moving	No connection to the stepper	• Check all pins at the motor connection to diagnose the port / cable; pin 5 should give +Ucc, pins 1..4 - 0V or +Ucc; Take power plug chassis or pin 7 as GND reference
Stepper becomes very hot	Coils have resistance below safety limit (0.5A / phase) Permanent overcurrent may destroy the motor and / or trigger the overcurrent protection circuit	• Add 10Ω resistors in line with each coil (pins 1..4)
No reception of PC commands	Communication faulty	• Check the port number and reconnect • Reconnect module / cycle power
After pressing „UP” button (green or red) the motor moves the opposite direction	Direction parameter set / not set	• Change motor direction (ref. Manual programming)

Safety and warranty

MK-Astro warranties the product will operate in accordance with specifications for one year following the original date of purchase. The manufacturer bears no responsibility whatsoever for damages / resulting damages / damages for 3rd parties, associated with the use of the product. Operation of the device must fall within normal limits, present to astronomy hobby. User must ensure avoidance of excessive force, heat, vibration, moist / humidity and temperatures outside design limits (-20C…+70C for storage, -15C…+30C for operation).

Warranty covers proper operation for one year from date of purchase. User induced damages, including:

- Electrical damage to I/O ports
- Mechanical damage
- Flooding with liquids
- Unauthorized repair / opening of the device

void warranty.

MK-Astro reserves the right to introduce technical changes in the device without prior notice.